Application Note AP_25 V01
28th Jan 2024

Choosing the Optimal Encoder for Linear Motors in Industrial Applications

INTRODUCTION

Linear motors are becoming a prevailing drive mechanism for many industrial applications, offering high velocity, force and acceleration, which makes them suitable for many industrial applications. The challenge, however, is that such motors must operate in closed loop and require an encoder that is equally robust.

This document analyzes several types of Encoder technologies for the implementation of Industrial Applications, while emphasizing the advantages of capacitive encoders as the optimal solution for such an environment.

THE INDUSTRIAL ENVIRONMENT

Industrial applications are characterized by long mechanical travel, vibration, high temperature range, airborne particles, and gaseous contamination.

Furthermore, linear motors generate magnetic fields around them. The selected encoder should be resilient to the above conditions.

COMMON LINEAR ENCODER TECHNOLOGIES

Following review [1], analyzes the differences between Capacitive, Magnetic & Optical Encoders solutions, and outlines the results.

Encoder Type	Capacitive	Optical	Magnetic
Resistance to Dirt, Dust, Oil	High	Low	High
Accuracy	High	High	Low
Temperature Range	Wide	Medium	Narrow
Current Consumption	Low	High	Medium
Programmability	Yes	No	No
Package Size	Small	Medium	Medium
EMC Immunity	High	High	High
Magnetic Immunity	High	High	Low [2}
Resolution Range	Wide	Wide	Narrow

The advantage of Capacitive sensing in a linear motor's application is clearly apparent.

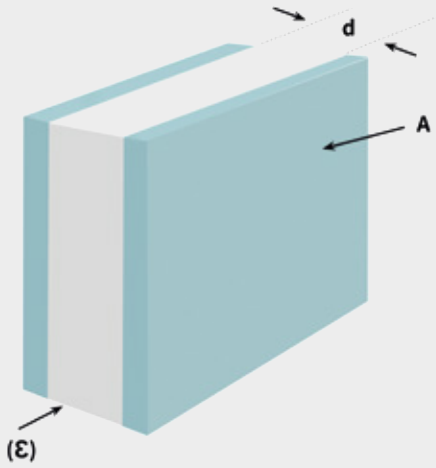
OPERATION TOLERANCES

Another very important aspect relates to mounting and operation tolerances, as those of the capacitive encoder are much more relaxed. This stems from the inherent physics of the sensing method.

In a capacitive sensor, the position is proportional to the common area between the stationary and the moving scales.

A – Common area
d - Spacing
ε – Dielectric constant of the medium

$$C = \frac{\varepsilon A}{d}$$



A major advantage compared to Optical and Magnetic encoders is the lower sensitivity to spacing.

- Capacitive reading changes according to d^{-1} as shown above.
- Optical reading changes according to d^{-2} (Divergence from a point light source)
- Magnetic reading changes according to d^{-3} (Magnetic Field H behavior)

FLEXe™

This clearly shows the major advantages of capacitive encoders in immunity to spacing changes. Indeed, while KappaSense's **FLEXe™** (https://www.kappasense.com/flexe/) offers a mounting tolerance of 2 ±1.5mm, a leading linear magnetic encoder manufacturer, on the other hand, quotes mounting surface quality of 50 microns (an Expensive process for the machine integrator/OEM !) and encoder mounting range of 0.1 – 0.3 mm. A leading optical encoders manufacturer quotes a ride height of 2.1 ±0.15, an order of magnitude more susceptive to spacing compared to the one offered by Capacitive technology!

KAPPASENSE FLEXe™ ULTRA FLEXIBLE FEATURES, ALLOWING MAXIMUM FLEXIBILITY FOR YOUR DESIGN!

Latteral Offset Tolerance (Y) = ± 2.5mm

Readhead stand-off (Z) = 2 ±1.5mm

Roll, Pitch & Yaw = 1 Deg

ADDITIONAL BENEFITS

KappaSense's Capacitive Encoders offer an Absolute reading as well. In Addition, It's **FREEe™** (https://www.kappasense.com/freee/) platform, offers a sliding readhead without cables, Making the application much simpler, less wiring, weight, and therefore a higher MTBF.

CONCLUSION

KappaSense's Capacitive Encoders are an ideal choice for linear motors & Industrial applications. Available in travels up to 2 meters and field proven in multiple demanding applications.

Kappasense Ltd is a Designer & Manufacturer of Absolute & Incremental Linear Capacitive Encoders since 2012, working with top Machines & Automation builders Worldwide and offering better solutions to today's Motion designs using its unique capacitive technology.

References

1. https://www.cuidevices.com/blog/capacitive-magnetic-and-optical-encoders-comparing-the-technologies#:~:text=A%20capacitive%20encoder%20is%20more,to%20vibration%20and%20temperature%20extremes

2. Extracted from a leading magnetic encoder vendor: Ferromagnetic plate is recommended, 0.5 to 1 mm thick, to cover coils and magnets near the sensor and at least 10 mm around it.